National Program 101 Food Animal Production
National Program Annual Report: FY2013

Introduction

The USDA-ARS National Program for Food Animal Production (NP 101) had another productive and dynamic year in 2013.

FY2013 featured the initiation of project plans for NP 101 which were developed from comprehensive stakeholder input gleaned from the NP 101 national stakeholder workshop. The workshop was jointly hosted by USDA-NIFA and brought stakeholders and the NP 101 research community together to prioritize the scope and direction of research in NP 101 and to discuss current and future areas of impact for the food animal industries. These efforts are documented online at: http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=101 and include: the ***Retrospective Review Panel Executive Summary***; the ***2011 Workshop Program and Summary***; and the ***FY2013-FY2018 Action Plan*** for NP101 which is now in effect as of October 1, 2012.

Food animal products fill a vital role in the diets of people around the world as valuable sources of high quality protein, fatty acids and minerals. The dramatic improvements in production efficiencies developed and harvested by ARS scientists help ensure international food security and directly impact human health and obesity by reducing the real cost of nutritionally valuable meat animal products, making animal products more available to those populations most in need. Ongoing improvements in production efficiencies also continually lessen the environmental impact of meat animal production by reducing grain and forage requirements and lessening the amount of manure produced. These improvements have dramatically reduced the amount of green house gas emissions produced by livestock and will continue to have impact.

NP 101 Vision Statement:

The vision for NP 101 is to furnish the scientific community and the food animal industries with scientific information, biotechnologies, and best management practices that (1) ensure that consumers have an abundant supply of competitively priced animal products that enhance human health, (2) ensure domestic food security, and (3) enhance the efficiency, competitiveness, and economic and environmental sustainability of the food animal industries.

NP 101 Mission Statement:

The mission of NP 101 is to foster an abundant, safe, nutritionally wholesome, and competitively priced supply of animal products produced in a viable, competitive, and sustainable animal agriculture sector of the U.S. economy by:

1. Safeguarding and utilizing animal genetic resources, associated genetic and genomic databases, and bioinformatic tools;
2. Developing a basic understanding of food animal physiology for food animal industry priority issues related to animal production, animal well-being, and product quality and healthfulness; and

3. Developing information, best management practices, novel and innovative tools, and technologies that improve animal production systems, enhance human health, and ensure domestic food security.

The scientific accomplishments of the USDA Agriculture Research Service and National Program 101 are truly remarkable and were again well documented in 2013. NP 101 scientists continue to make inroads toward a better understanding of food animal production challenges relating to genomic discovery science and application, growth and production efficiency, lifetime productivity, animal well-being, environmental adaptation, product quality and healthfulness, reduction of feed and energy inputs, enhancements in energy retention, and reduced environmental impact. Application of technologies developed or enhanced by NP 101 scientists promise to continue to address the high priority issues for consumers while enhancing the profitability and competitiveness of food animal producers across the United States in today's very competitive global agriculture community.

During FY 2013, 84 full-time scientists working at 11 locations across the United States were actively engaged in more than 140 independent research projects in the program. Research projects in NP 101 were approved through the ARS Office of Scientific Quality Review in 2012, making this the first year of implementation of these five-year project efforts. The gross fiscal year 2012 funding for NP101 was $47 million.

Personnel in NP 101

New additions to the NP 101 team in 2012 are:

Derek Bickhart, Beltsville, Maryland, joined the Animal Improvements Program Laboratory (AIPL) staff as a research geneticist. Previously, he was a postdoctoral fellow with Dr. George E. Liu at ARS's Bovine Functional Genomics Laboratory, where he had worked since August 2010 primarily on copy number variation. Bickhart received his M.S. (2009) and Ph.D. (2010) degrees from the University of Connecticut with a major in genetics and genomics. His skill in identifying useful genetic variants in full-sequence genotypes and his proficiency in managing large data sets will be important assets to AIPL.

Nicole Burdick Sanchez, Lubbock, Texas**,** joined the Livestock Issues Research Unit. Dr Burdick Sanchez has served as a research associate with the Livestock Issues Research Unit for the past 2.5 years. She completed her Ph.D. at Texas A&M University in 2010.

The following scientists retired from the ranks in NP 101:

Lee Alexander, Forage and Range Research Laboratory, Miles City, Montana.

Sherrill Echternkamp, US Meat Animal Research Center, Clay Center, Nebraska.

The distinguished record of service of these gentlemen is recognized world-wide and they will be missed in NP101.

The following scientists in NP 101 received prominent awards in 2012:

Tami Brown-Brandl, Clay Center, Nebraska, received a **Presidential Citation** from the American Society of Agricultural and Biological Engineers.

Jeff Carroll, Lubbock, Texas, received the **National Pork Board Research Innovation Award** at the 2013 American Society of Animal Science Southern Section Meeting.

Jeff Carroll, Lubbock, Texas, was awarded **the IEF Laboratories Award for Innovation in Pre-Harvest** at the Arkansas Association for Food Protection Annual Educational Conference, September 10, 2013, Fayetteville, Arkansas.

Larry Cundiff (retired), Clay Center, Nebraska, was elected to the **USDA-ARS Hall of Fame**.

John Grabber, Madison, Wisconsin, received the Journal of Agricultural and Food Chemistry **Research Article of the Year Award** from the AGRO Division of the American Chemical Society.

Tommy Wheeler, Stephen Shackelford, and **Andy King**, Clay Center, Nebraska, were recognized by the American Meat Institute Foundation with the **Scientific Achievement Award** for "Outstanding scientific contributions in improving the production, quality and safety of meat products through applied, basic, and discovery research".

Tommy Wheeler, Steven Shackelford and **Andy King**, Clay Center, Nebraska, were recognized by Mid-Continent Federal Laboratory Consortium for **Excellence in Technology Transfer** for their "VBG2000: Beef Carcass Grading System".

Tommy Wheeler, Clay Center, Nebraska, was recognized by the American Meat Science Association with the **Distinguished Research Award** for "Outstanding research contributions to the meat industry".

Tommy Wheeler, Clay Center, Nebraska, was recognized by ARS Northern Plains Area as the **Outstanding Senior Scientist of the Year**.

The quality and impact of NP 101 research was further evidenced in 2013 by following:

- Over 170 refereed journal articles published
- Four new cooperative research and development agreements with stakeholders
- Twenty-six new scientific technologies developed relating to genomics and other research, and
- Administration or development of ten web sites for academia or stakeholders

In 2013 NP 101 scientists participated in research collaborations with scientists in: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Denmark, Egypt, France, Germany, India, Ireland, Israel, Italy, Kenya, Mexico, Netherlands, New Zealand, Nigeria, Norway, Russia, Saudi Arabia, Scotland, South Africa, Spain, Sweden, Switzerland, Tunisia, Turkey, Uganda, United Kingdom and Uruguay.

Major Accomplishments in 2013

This section summarizes significant and high impact research results which address specific components of the FY 2013 – 2017 action plan for the Food Animal Production National Program. Each section summarizes accomplishments of individual research projects in NP101. Many of the programs summarized for FY 2013 include significant domestic and international collaborations with both industry and academia. These collaborations provide extraordinary opportunities to leverage funding and scientific expertise for USDA - ARS research to ensure international food security by rapidly disseminating technology that enhances the productivity and efficiency of meat and milk production. Improved production efficiencies decrease the real cost of food and animal products and make these products more available to people worldwide.

NP 101 Top Accomplishments – FY2013

Development of international genomic evaluations for young dairy bulls

Genomic evaluations have rapidly replaced traditional evaluation systems used for dairy cattle selection and have had tremendous impact in increasing genetic progress. However, accurate, unbiased comparison of genomic evaluations from different countries has not been possible because of differences in national methodologies and data included in evaluations. ARS scientists collaborated with the Canadian Dairy Network (Guelph, Ontario) and the Interbull Centre (Uppsala, Sweden) on a genomic multitrait across-country evaluation (GMACE) system which was developed by modifying techniques used in traditional international evaluations. Initial implementation of GMACE for young Holstein bulls was completed in August 2013 by Interbull Centre. The availability of accurate, international genomic evaluations for young bulls will allow breeders to now select globally from the best animals, thereby providing access to a much larger genetic pool and increasing the rate of genetic progress for dairy production worldwide.

Identification of engineered antimicrobial proteins that eradicate staphylococcal mastitis pathogens in dairy

The U.S. dairy industry loss due to mastitis (infections of mammary glands) exceeds $2 billion annually. Mastitis is also responsible for the greatest use of antibiotics on the dairy farm despite an international effort to reduce antibiotic use in agriculture. The bacterial pathogen, *Staphylococcus aureus*, can evade most conventional antibiotics by invading and residing inside the cells (intracellularly) of the cow mammary gland, leading to chronic infection and increased culling of infected animals. Conventional antibiotics do not kill intracellular pathogens. Thus, novel antimicrobials that were effective at killing intracellular bacteria would benefit the dairy industry for the treatment of mastitis and help to replace antibiotics that are facing high levels of resistant strain development. ARS scientists in Beltsville, Maryland, demonstrated that an engineered antimicrobial protein facilitates transport across the mammary cell walls into intracellular spaces. Scientists then fused the protein to a previously engineered antimicrobial protein with three distinct enzyme activities. The top-candidate engineered antimicrobial protein, for the eradication of intracellular *S. aureus* in cultured cell assays, showed the ability to reduce the *S. aureus* infection 1000-fold in a mouse mastitis model. This technology presents a novel alternative mastitis treatment to effectively treat and potentially eliminate bovine mastitis; and thus significantly reduce the need for conventional antibiotic use on the dairy farm.

New semen extender supplement improves the fertility of turkey semen

The turkey industry relies exclusively on artificial insemination, a time and labor-intensive process, to reproduce birds in commercial operations. When producers use freshly collected semen for artificial insemination, fertility rates are typically 94-98%; however, if semen is held for longer than 6 hours prior to insemination, fertility rates drop to 40%. ARS scientists in Beltsville, Maryland, evaluated the biological basis for this drop in fertility, and have shown that the sugar residues on the surface of the sperm membrane change when semen is held for longer than 6 hours. To address this issue, an intensive evaluation of the concentration of different sugars, as well as the effect of time and temperature on these sugars was conducted. Results indicate that providing extra sialic acid (sugar) in the semen extender can boost the fertility rates of semen held at a cool temperature (4C) for 24 hours from 40% to 85%. This represents a significant advance in poultry semen storage technology that will save producers time and money when reproducing flocks.

Bacterial communities in the rumen differ in high-efficiency versus low-efficiency dairy cows

Milk production in cows is influenced by a number of factors, including diet, host genetics, and the bacterial communities in the rumen. Rumen bacteria are directly responsible for the production of volatile fatty acids (VFA) that are used by the cow as precursors for milkfat synthesis. ARS researchers in Madison, Wisconsin, in collaboration with the University of Wisconsin, characterized the total ruminal bacterial community and VFA profiles in eight Holstein dairy cows. These cows were separated into high- and low-production efficiency groups, and both rumen solids and liquids were analyzed for total bacterial community structure. The researchers identified significant differences in bacterial community composition between high- and low-efficiency groups and between the solid and liquid fractions. They also identified a core set of bacterial species shared among all high-efficiency cows, with no similar core set among the low-efficiency animals. Chemical profiles between high- and low-efficiency groups were similar, but propionic acid concentration was significantly higher in low-efficiency cows, and succinic acid was significantly higher in high-efficiency cows. These results show that there is a specific ruminal bacterial community associated with feed efficiency in dairy cows, but these differences cannot be detected by simple chemical analysis of rumen contents. Further research is needed to leverage these results to promote improved nutrient utilization efficiencies for the dairy industry.

Finding markers to predict reproduction efficiency in beef cattle using a Genome Wide Association Study (GWAS) approach

Reproductive efficiency is arguably the most economically important trait in commercial beef cattle production, as failure to achieve pregnancy reduces the number of calves marketed per cow exposed to breeding. Identification of variation in the genome with predictive merit for reproductive success would facilitate accurate prediction of daughter pregnancy rate in sires and enable effective selection of bulls whose daughters have improved fertility. Scientists at Clay Center, Nebraska, applied a Genome Wide Association Study (GWAS) approach, using a procedure based on genotyping multi-animal pools of DNA to increase the number of animals that could be genotyped with available resources. The study identified regions of the genome associated with reproductive efficiency, which are being targeted for further analysis to develop robust marker systems, and demonstrated that DNA pooling can be used to substantially reduce the cost of GWAS studies in cattle. A specific deletion of DNA along chromosome 5 in Bos indicus crossbred cattle was identified that is strongly correlated with reproductive failure, providing a potentially useful marker for breeders in sub-tropical areas that make use of these types of cattle. These results demonstrate the ability to leverage the bovine genome sequence to improve reproductive efficiency in beef cattle for the beef industry while significantly reducing technology costs for research communities.

Lysozyme is an alternative to antibiotics for young pigs consuming manufactured liquid diets

Antibiotics have been fed at subtherapeutic levels as growth promoters for more than 50 years, and the majority of swine produced in the United States receive antibiotics in their feed at some point during the production process. The addition of antibiotics to swine diets benefits producers by improving feed efficiency and decreasing susceptibility to bacterial infections. Recently, however, swine producers have been pressured to reduce or remove dietary antibiotics in response to concerns relating to the development of antimicrobial resistance in swine production. The identification of suitable alternatives to antibiotics will enable the swine industry to effectively transition away from dietary antibiotic use. ARS scientists at Clay Center, Nebraska, determined that feeding a natural antimicrobial, lysozyme, to young pigs consuming a liquid diet was as effective as antibiotics in increasing growth performance,

improving gastrointestinal health, and decreasing pathogen shedding. This research has demonstrated an effective alternative to traditional antibiotics in swine diets for improved health, well-being, growth, and efficiency.

Influence of calving date on reproductive traits in beef cattle

Studies conducted by ARS researchers at Clay Center, Nebraska, in collaboration with South Dakota State University and the University of Nebraska confirmed that heifers that calve early in their first season remain in the production herd longer, increasing the profitability and viability of a beef production enterprise. Earlier calving heifers weaned heavier calves through their first six pregnancies, resulting in increased revenues of $500-$2000 per heifer across varying herd sizes and production systems. Additional results demonstrated that heifers that calved later and were culled from the herd earlier had smaller ovaries, and reduced uterine horn diameters along with fewer follicles in their ovaries. Collectively, these results indicate that pre-breeding ultrasonic evaluation of the reproductive tract can be a useful tool for removing less productive heifers from the herd prior to first breeding, and promoting early season calving for heifers will significantly improve reproductive efficiency in the cow herd.

Copper sulfate and zinc oxide differ in induction of cross-resistance of bacteria in growing pigs

Increased pressure to move away from antibiotic use in swine makes it imperative that alternatives which promote health, growth, and efficiency be discovered. Copper sulfate and zinc oxide have been extensively used as alternatives to antibiotics for health and growth promotion in animal production. However, concerns regarding bacterial cross-resistance between these compounds and antibiotics are emerging. ARS researchers at West Lafayette, Indiana, discovered that copper sulfate and zinc oxide differed in their ability to induce antibiotic resistance. Zinc did not affect bacterial responses to antibiotics, however copper sulfate had varied effects, depending on the targeted bacterial strain. Thus zinc supplementation will not affect antibiotic use in pigs whereas supplementation with copper may allow bacteria to become resistant to antibiotics, compromising animal health and well-being as well as growth and efficiency.

Significant improvements in the bovine genome sequence

Gene expression is regulated by transcription factors that link or bind to specific genes, which in turn signal the production of proteins or other gene products. Understanding the complex interaction of the genome and specific gene expression would be significantly improved with a more complete understanding of transcription factor binding sites. ARS scientists in Beltsville, Maryland, identified ~380,000 candidate transcription factor binding sites (TFBS) for ~8,000 annotated genes in the cattle genome and the intersection of several hundred gene mutations (SNPs) and TFBS. This novel bovine TFBS information will greatly facilitate ongoing cattle genome sequence annotation. Newly identified SNP–TFBS intersections represent high priority regions of interest for follow-up studies such as RNA-seq, QTL mapping and GWAS in order to link gene variants within TFBS to phenotypes. In related work ARS scientists developed an innovative computer approach to detect copy number variation (CNV) using novel sequencing technologies for the bovine genome sequence. CNV regions are a key source of genetic variation in cattle, but are not yet well cataloged or understood. This program generated thousands of new CNV regions, which will enable future studies of these highly variable regions in the cattle genome. Specifically, this software will provide a “second-generation” cattle CNV map - a crucial resource for industry and academic genotyping technologies and industry wide sequencing efforts like the 1000 Bull Genome Project. This technology will also significantly improve

the cattle reference genome and its annotation by filling in novel sequence information and can be easily re-purposed for other livestock species.

Understanding the variation in genetic resistance to Marek's disease in poultry

Enhancing genetic resistance to Marek's disease (MD) in chicken, a complex trait controlled by many genes, is highly desired to augment current controls through vaccines and biosecurity. Using genetic markers spaced throughout the genome, an ARS scientist in East Lansing, Michigan, in collaboration with Purdue University demonstrated that those markers associated with variation in gene expression account for all the genetic variation in an experimental population. If confirmed in commercial poultry lines, this would prove that genomic selection with these types of genetic markers would significantly improve elite poultry lines against MD, and is likely to be the case for genetic resistance to other infectious pathogens as well. Ultimately, poultry producers and U.S. consumers would benefit through the production of healthier and more efficient birds yielding more economical poultry products.

Introduction of free genetic tests for inherited defects of dairy cattle

A method to identify exact locations of loss-of-function mutations and DNA sequences associated with lethal or undesirable conditions of dairy cattle was developed by ARS scientists in Beltsville, Maryland, and automated over the past two years. However, results from that method could not be made available to the dairy industry because the respective DNA sequences were associated with patented genes. Genetic tests were available for some of the lethal mutations, but most females were not tested because individual gene tests were expensive and not included on genotyping chips until very recently. The June 2013 U.S. Supreme Court unanimous decision that biotechnology companies cannot patent genes that occur naturally has made possible the release of information from genetic tests for bovine leukocyte adhesion deficiency (BLAD), deficiency of uridine monophosphate synthase (DUMPS), and mulefoot in Holsteins; as well as Weaver Syndrome, spinal dysmyelination (SDM), and spinal muscular atrophy (SMA) in Brown Swiss. For Holsteins, the method also can be applied to identify DNA markers associated with complex vertebral malformation (CVM) and brachyspina as well as for desired traits such as red coat color and polledness (no horns). In addition, four new deleterious DNA sequences have been identified for dairy cattle fertility, and those sequences have been incorporated into new genotyping chips. The first release of genomic status information for the inherited defects occurred in August 2013 and is expected to provide the tools for dairy producers to reduce or eliminate costs for genetic testing, decrease the frequency of undesired traits, and increase the rate of genetic progress for desired traits through significant improvements in reproductive efficiency, health, and animal well-being.

Freezing then thawing and aging beef improves meat tenderness.

An unacceptably high percentage of beef top loin and sirloin steaks are tough and result in consumer dissatisfaction, particularly those from cattle fed specific growth and development enhancers. ARS scientists at Clay Center, Nebraska, determined that freezing, then thawing and aging beef resulted in significant improvement in meat tenderness for the toughest cuts in a beef carcass. The range of improvement in tenderness averaged 22% across the study, but varied from 0 to 46% depending on the individual and production system. This strategy could be implemented for all high-priced meat cuts with high quality expectations to ensure tenderness and improve consumer satisfaction, or it could be selectively implemented only on those meat cuts identified as high risk to produce tough steaks. This strategy would also enable the beef industry to better manage frozen product stocks to optimize quality and inventory year round.

Appendix 1). Additional Significant Accomplishments for NP 101 in FY 2013 by Subject Matter Section One: Genetics, Genomics and Meta-genomics:

Development of a genomic mating program for dairy cattle to minimize inbreeding

Breed associations, artificial-insemination organizations, and on-farm software providers have needed new computerized mating programs for genomic selection so genomic inbreeding could be minimized by comparing genotypes of potential mates. ARS scientists in Beltsville, Maryland, developed novel methods for transferring genomic relationships from a central database to customers. Methods were also developed and tested by ARS to consider dominant (non-additive) genetic effects of individual markers when assigning mates to further improve the merit of offspring. Mating programs that included genomic relationships are more effective than those using pedigree relationships because they improve the expected value of offspring as well as decrease expected offspring inbreeding. The resulting decrease in inbreeding is estimated to return over $3 million annually for U.S. Holsteins. That economic value is additive and will grow as more cows are genotyped. This program will also be applied to additional dairy breeds in the future.

First national genomic evaluations for Ayrshire dairy cattle

The national genetic evaluations of the Holstein, Jersey, and Brown Swiss dairy breeds in the United States have benefited from the inclusion of genotypic information since 2009, but too few Ayrshires have been genotyped to allow genomic evaluation. ARS scientists in Beltsville, Maryland, using data from over 1,100 genotyped Ayrshires with performance and pedigree records in the North American database, developed the first genomic evaluations for Ayrshires. Compared with traditional parent averages, those evaluations improved accuracy of prediction of genetic merit by 8.2 percentage points over all traits (17 percentage points for milk and protein yields and 16 percentage points for stature). The availability of genomic information also made breed determination possible using procedures that had been implemented for other breeds. In addition, a DNA segment (haplotype) that decreases fertility was discovered on autosomal chromosome 17; sire conception rate was 3.0 percentage points lower for carriers of the haplotype, and the carrier frequency for genotyped Ayrshires is 23%. Ayrshire breeders will be able increase the rate of genetic gain for economically important traits and improve fertility as a result of improved knowledge of the genomic makeup and merit of their animals.

Low-cost genotyping tools for genomic predictions of genetic merit

Better, low-cost tools for genotyping are needed, including parentage tests and other important DNA tests of economically important traits for the industry. ARS scientists in Beltsville, Maryland, continue to provide leadership in DNA tool development for ruminants to provide low cost opportunities to obtain the genetic information needed for genomic selection in the U.S. beef cattle industry and globally for tropically adapted cattle. These tools also allow DNA service providers to transition from "old technology" to SNP-based technology for parentage determination. The North American dairy industry continues to use products developed by ARS at a rate of genotyping more than 15,000 new animals per month; and development of a SNP genotyping tool for water buffalo has the potential to increase the accuracy and efficacy of genomic selection for improved dairy production in the developing world.

Novel application of rumen metagenomic DNA sequencing technology to reduce impacts of environmental contaminants

Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) is a powerful explosive compound that has been used by the U.S. military since WWII to manufacture weaponry. Soil and groundwater contamination by RDX is a serious concern due to its toxicity and potential carcinogenicity. Traditional methods for its cleanup

include extensive excavation and subsequent incineration, which are cost prohibitive. The sheep rumen harbors microorganisms that are capable of rapid RDX biodegradation and may provide a practical remediation alternative; however, the microbial taxa performing RDX biodegradation are unknown and metabolic pathways through which RDX is degraded have not been analyzed. ARS scientists in Beltsville, Maryland, in collaboration with scientists at Oregon State University, conducted a holistic analysis of the ovine rumen microbiota. It was demonstrated that the ovine rumen can significantly reduce and eliminate RDX in a model system within hours. Gene sequence analysis identified known microbial groups capable of RDX degradation in the sheep rumen and several microbial groups of environmental origin that were not previously recognized in the rumen. These results enable the refinement of a new remediation technology that combines plant intake of explosive compounds from contaminated soils and their biodegradation by ruminal microbes of sheep that graze on these plants, and may lead to additional technologies to reduce or eliminate environmental contaminants using the rumen microbiome.

Discovery of genetic markers associated with feed efficiency in beef cattle

Residual feed intake (RFI), the difference between the amount of feed that an animal is expected to consume and the actual amount consumed, is a measure of feed efficiency. Feed is the highest cost of beef cattle production. Consequently the ability to select animals genetically that are more efficient results in cost savings for producers, as these animals will consume less feed per unit of performance. ARS scientists in Clay Center, Nebraska, identified six novel genetic markers that are predictive for differences in feed efficiency in beef steers located on bovine chromosome 14. These markers were also evaluated for their effects on meat quality and carcass traits to determine whether they would impact weight and eating quality. The markers were not associated with marbling and tenderness, and are thus unlikely to impact beef quality. The markers identified are being further validated by ARS and should be useful to the beef industry for the genetic selection of improved feed efficiency in beef cattle.

Identification of DNA markers predictive of puberty in gilts

Approximately one-third of female pigs (gilts) selected for breeding are culled due to failure to reach puberty and become pregnant. ARS researchers at Clay Center, Nebraska, discovered 12 genetic markers that were associated with failure of gilts to reach puberty. These markers are being further validated by ARS, but should allow for selection of gilts that will reach puberty and become pregnant, thereby increasing reproductive efficiency and reducing costs and inefficiencies in the pork industry.

Identification of physiological mechanisms and genes controlling feed intake, reproduction and growth in swine

Feed costs account for approximately 72% of the variable cost of pork production. ARS researchers in Clay Center, Nebraska, discovered that the protein nesfatin-1 controls appetite in the pig and found that genetic markers in the nesfatin-1 gene were significantly correlated with body weight at puberty. These new genetic markers will be used in marker assisted selection to improve feed efficiency, better manage growth and target weights for breeding gilts, resulting in improved reproductive and production efficiencies in the pork industry.

Section Two: Reproductive Physiology:

Development of semen cryopreservation methodology for a unique commercial turkey line.

Cryopreserved turkey semen historically yields very low fertility rates (0-5%) that prevent any meaningful application of commercial semen repositories for the long-term preservation of genetics. ARS scientists in Beltsville, Maryland, tested semen freezing and resulting fertility rates on a specialized

line of turkeys that was no longer needed for production but might be valuable in the future. After examining 14 variations in semen freezing methods, a novel approach was discovered that increased fertility rates to 26% over 3 consecutive weeks, with 100% of the fertile eggs hatching live, healthy poults. This breakthrough resulted in sperm from the first commercial turkey line to be cryopreserved and stored in the USDA's National Germplasm Facility with proven potential for future line regeneration for the turkey industry.

Improved method to determine egg fertility

Poultry industry hatchery managers need a quick and easy way to differentiate between fertilized, unfertilized and non-viable embryos that die very early during incubation. The embryo develops on the surface of the egg yolk underlying a thin fibrous investment surrounding the yolk. Sperm must penetrate this investment to fertilize the ovum. ARS scientists in Beltsville, Maryland, modified an existing procedure used to isolate unincubated embryos so the path of the sperm penetrating the fibrous investment can be made visible. This modification permits the rapid assessment of the actual number of sperm interacting with the hen's ovum, resulting in an algorithm that can be used to predict the duration of fertility. The new technique has been use to significantly increase the accuracy of assessment of eggs from ducks, quail, chickens, geese, and turkeys for incubation success.

Section Three: Growth Physiology, Nutrient Use Efficiency and Nutrient Cycling:

Identification of a major blood protein that inhibits fat accumulation in neonatal pigs

Growth in the young pig is characterized by fast rates of muscle protein accumulation and very low rates of fat accretion, despite the consumption of a high fat diet. The identification of biological or genetic markers for growth is critical for the breeding of lean, efficient and fast growing pigs and reducing neonatal piglet mortality is a key profitability factor for pork producers. ARS scientists in Beltsville, Maryland, identified a growth related marker (alpha 1 acid glycoprotein, AGP) that is elevated in poorly growing neonatal piglets, but that also reduces the expression of genes associated with lipid synthesis by up to 80%. These data indicate that AGP may contribute to limiting the rate of fat accumulation in the neonatal pig. This inhibition of fat growth by AGP is currently being examined but may be problematic for the neonatal piglet by limiting the development of adequate energy stores, resulting in poor growth performance or poor survival. This marker may also have further implication in other species with relation to lean and adipose deposition, nutrient utilization efficiency, obesity, and growth rate.

More accurate assessment of nitrogen use will aid in reducing greenhouse gas emissions from the global dairy sector

The anticipated increases in global demand for food, especially for animal products, necessitate an urgent search for practices that enhance nitrogen use efficiency and reduce environmental nitrogen loss (ammonia, nitrate, nitrous oxide) from agricultural production. The International Panel on Climate Change requires member countries to determine and report agricultural greenhouse gas emissions. In an effort to provide more accurate information for countries making these assessments, an ARS scientist from Madison, Wisconsin, was assigned to the Food and Agriculture Organization of the United Nations, Animal Production and Health Division, to analyze data on dairy cattle populations, feed, and milk production from 144 countries and determine more accurate values for nitrogen use efficiency and manure nitrogen excretion. These values may now be used to more accurately estimate ammonia and nitrous oxide emissions from the global dairy sector. The improved accuracy of manure nitrogen excretion calculations derived from this study will enhance regional, production system, and global determinations of nitrogen loss from dairy farms during the collection, storage, and land application of

manure, and will more accurately reflect the amount of manure nitrogen actually recycled through crops and pastures by the dairy industry.

A novel objective indicator of the nutritional status of range beef cows

The major challenge for beef producers is providing sufficient nutritional inputs to cows to ensure timely rebreeding while minimizing feed expenses. ARS scientists in Miles City, Montana, discovered that beta-hydroxybutyrate (ketone) in the blood stream is an accurate and objective indicator of the nutritional status of cows. Cows with greater levels of ketones in their blood took longer to become pregnant than cows with lower levels. Research validated the use of an inexpensive hand held meter and commercially available test strips as a method for on farm or ranch measurement of beta-hydroxybutyrate, thereby providing producers with an objective method to access cow nutritional status. This will enable producers to optimize reproductive efficiency and nutritional costs.

Feed efficiency in growing heifers compared with feed efficiency as lactating beef cows

Residual feed intake (RFI) is an indicator of feed efficiency that measures variation in feed intake independent of body weight, growth rate, and milk production. Feed makes up about two-thirds of costs for a finished beef carcass, and mature cows consume the majority of the feed required to produce that carcass. Therefore, improving feed efficiency in the cow-calf unit is one way to lower production costs. Studies using growing animals have shown moderate levels of heritability for RFI; however, few studies have compared an individual animal's RFI between two physiological states, e.g., growing heifer and lactating cow. In the beef industry, it is common to measure feed efficiency as a growing heifer and then to assume that this efficiency is representative of that individual as a cow producing a weaned calf. ARS scientists and colleagues at the University of Florida in Marianna, Florida, evaluated whether RFI as heifers is an indicator of subsequent RFI as a mature cow, including overall performance and temperament. Mature cow body weight, condition score, daily gain, milk production, backfat, ribeye area, and RFI was similar among the RFI groups determined as heifers. However, the rank correlation between RFI as heifers and RFI for the same animals as cows was very low. Results did indicate that the most efficient heifers consumed less feed, both as heifers and as cows, but estimating RFI on heifers is a poor indicator of efficiency of those heifers as cows, other than perhaps reducing feed intake.

Section Four: Animal Stress and Well-Being:

Mitigating environmental heat stress in poultry

Heat stress events in the United States cause significant economic loss to poultry producers and are deleterious to poultry welfare by compromising both production and survivability. ARS scientists in West Lafayette, Indiana, found that a dietary supplement that serves as an anti-oxidant decreases the negative effects of heat stress by decreasing both physical and physiologic damage in laying hens. This phenomenon is being further evaluated by ARS, but the development of feeds providing high levels of anti-oxidants may prove useful for combating the negative effects of heat stress and to improve hen productivity and welfare.

Development of a new shade structure for commercial beef feedlots

Shade has a positive effect on reducing stress in feedlot cattle, but implementation is limited due to cost and maintenance issues. Shading materials vary in price and effectiveness, with each material having its own benefits and challenges. Initial instrumentation tests conducted by ARS scientists at Clay Center, Nebraska, determined that even a minimal shade offers enough protection to reduce the thermal index by one category (emergency to danger–danger to alert, etc.). Animal tests using three different types of shade (100% shade cloth, 60% shade cloth, and snow fence) were completed. Initial analysis showed

that all materials were effective in reducing respiration rates and associated heat stress. Subsequently, a shade structure was designed by ARS according to the following criteria: cost, effectiveness, durability, low maintenance, and minimal interference with normal feedlot management. The design integrates animal/shade response data collected over the last decade. Eight, 10-m tall by 15.4-m long structures were installed at the U.S. Meat Animal Research Center feedlot in Clay Center, Nebraska. These north/south structures were fitted with four 15.4-m lengths of poly snow-fence, and provided an effective 50% shade coverage that tracks the sun during the day and offers up to 3 m^2 of shade per head. Animal performance and shade longevity and cost effectiveness of these structures is currently being evaluated for development and application to the beef industry.